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The Production of Improved Tomato Varieties

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THE PURPOSE of this paper is to discuss those issues which influence the aims and methods of tomato breeding, and to describe some of the work in progress at the Glasshouse Crops Research Institute. More general reviews of tomato breeding¹ and of plant breeding methods² have been published recently.

The Problem

The geneticists' maxim, that the genotype interacts with the environment to produce the phenotype, is true for all organisms; and if we rephrase this in more general terms it becomes: the variety and the growing conditions determine the crop which is harvested. For certain horticultural crops the seed is undoubtedly much cheaper than the provision of suitable growing conditions, for which both high capital investment and considerable recurrent expenditure are necessary to provide the glasshouse and its heating system, labour, fuel, fertilizers, fungicides, and many other items.

As with all crops, the plant breeder lays the foundations, and the greater the potential of the variety by the incorporation of desirable characters which can be exploited in the crop culture, the better it is for the grower. When creating new tomato varieties, the breeder must take note of the requirements of all those people who are concerned with the production and consumption of the fruit, and this includes the seed producer, the grower, the transporter, the marketer, the purchaser, and the consumer.

THE SEED PRODUCER

It is important that seed of a variety should be producible in quantity with minimum cost, and the commercial company which promotes tomato breeding prefers, for economic reasons, to retain complete control of that seed production.

THE GROWER

The ultimate aim of all tomato growers is to produce and sell as profitable a crop as possible, and this involves consideration of costs, crop weight, fruit quality and time of production. However, their facilities and cultural methods differ considerably, so it is important that a range of varieties should be available to the industry to permit each grower to choose the one most suitable for his conditions.

Perhaps of greatest importance is the type of vegetative plant on which the fruit is to be borne, and when classified by reference to plant-

habit three main groups of varieties can be distinguished. Compact habit is typified by the variety Baby Lea with its short drooping leaves, short internodes, close trusses, and restricted root system. Plants in the largest group have a tall spreading habit with strong growth both above and below soil level, as seen in the varieties Ailsa Craig and Ware Cross. Plants of Potentate have an intermediate habit which is between the other two types in height, leaf spread, and root development. In view of the large differences between these groups and their differential suitability for use in contrasting types of culture, e.g., early versus late, heated versus cold, steamed versus non-steamed soils, it is desirable that any variety with a particular combination of valuable fruit characteristics should be available with the three contrasting habits.

Fuel and labour are the two most expensive items in tomato production and any variety which leads to a saving on these costs is most useful. Earliness and total crop weight are of great importance, and with the trend towards finishing crops in August, heavy mid-season bulking-up is desirable. With intensive production in the sheltered luxurious conditions of a glasshouse, pests and diseases can be most troublesome. Genetic resistance to such troubles is increasingly desirable as the cost of chemical control measures rises, and some of the latter are of limited use because of phyto-toxicity hazards. The fruit which the grower sends to market must satisfy the transporter, the marketer, and the consumer, and their requirements are mentioned briefly.

THE TRANSPORTER

A firm fruit which travels well is of paramount importance, though whether this is best achieved by selecting for varieties with three or four locule walls to give internal strength, with a thick outer wall, or with high turgor is not yet clear. A short stalk is desirable to prevent puncturing and a thick skin may be more robust, though the consumer would deny its palatability.

THE MARKETER AND PURCHASER

For these people the visual aspects of quality are the dominating features of tomatoes. Fruit size, shape, and colour determine the presentation, suitability for prepackaging, and the ability to attract attention and encourage a purchase. In general the smaller fruited varieties have better fruit shape and colour, but they do not usually bear the heaviest crops.

THE CONSUMER

Texture and flavour are his concern, though of course personal likes and dislikes vary considerably. Taste is a very individual sense, depending on the genotype and oral environment of the eater, as well as on the tomato variety, its culture, the stage of maturity when the fruit is picked and its subsequent treatment before consumption.

Facilities and Difficulties

There are advantages and disadvantages associated with the breeding of any crop plant. These depend on the natural breeding system of the species, the range of variability available, the characters for which selection is to be effected, the method of seed production, the mode of propagating the crop by the industry and the general cultural methods employed, and the economics of management and marketing. All these factors will influence the techniques which are used for breeding new genotypes and for assessing their potential in comparison with existing varieties.

On the credit side, the English tomato is a self-pollinating inbreeding species which can be propagated vegetatively if required to maintain a particular breeding stock. Emasculation and cross-pollination are simple processes, there is a relatively large number of seeds resulting from each pollination, and seed saving is a simple process. These advantages mean that it is relatively easy to use the various breeding methods described below, but there are other features which make the selection and assessment of new varieties rather difficult.

EXPRESSION OF CHARACTERS

Reference has already been made to the many characters which need to be incorporated in a tomato variety. For some of these characters extreme expression is required, e.g., freedom from fruit pigment disorders, but for others it is necessary to breed a genotype which will give a phenotype at some intermediate point in the range of character expression. Optimum fruit size is an example, and it is difficult to select and fix this type of character. This particular problem is further complicated by the fact that fruit size interacts with fruit number to determine total crop weight, and of course the expression of this last character should be maximal.

Tomatoes are grown in, and varieties must be selected for, a wide range of growing conditions. Because many environmental factors can be controlled this tends to lead to a multiplicity of combinations involving the time of cropping, soil type and fertility, nutrition, watering, air temperature, soil temperature, day temperature, night temperature, humidity, and shading, all of which interact with light which varies in intensity, duration and quality. Considerable expenditure is required to provide and maintain the glasshouse environment and this, coupled with the relatively large ground area and high labour input required for each plant, imposes severe limitations on the numbers of plants which can be grown in a breeding programme.

ENVIRONMENTAL EFFECTS

The man-made environment often results in gradients of temperature, light and exposure which are detected as differences in plant growth and cropping. This leads to great hazards when attempting single plant

selection, yet it is rarely practicable to conduct extensive progeny testing owing to the limitation on the number of families that can be grown. For trials it is preferable to use balanced statistical designs which permit the elimination of north-south and east-west environmental effects, and the Trojan Square design³ is very suitable. Usually it is necessary to employ plots comprising very few plants and this can be most unsatisfactory, especially if many plants succumb to disease or suffer damage.

Further difficulties arise because of the extended cropping period of tomatoes, as a variety trial may require harvesting two or three times each week for twenty-five weeks, and also because of the variable nature of the fruit from any single plant or experimental plot. Four select and two lower grades are recognized by the Tomato and Cucumber Marketing Board and there is usually some sub-standard fruit which is still saleable. These different qualities command different prices which vary with the time of year, the prevailing weather, national holidays, and the market supplied.

Because of the very high labour requirement for grading and recording, and the fruit's fluctuating value, the accurate assessment of single plants is virtually impossible on a large scale, but to trust general impressions of plants, say, in May, when some fruit has been harvested and some fruit has not even been produced, is most hazardous. Increasing attention is being given to the economic evaluation of tomato genotypes as well as to sampling techniques which would minimize the amount of data to be collected from trials.

Breeding Methods

PURE-LINE METHOD

In its simplest form this involves cross-pollinating pre-existing genotypes, and then by selecting, self-pollinating and saving seed separately from single plants for a number of generations, true breeding lines with new combinations of characters derived from both parents can be established. The method is suitable for breeding tomatoes, especially when characters of complex inheritance are involved, and many of our straight varieties have been produced in this way. For the various reasons mentioned earlier the chief difficulty is in deciding which plants to select and seed, especially as the programme proceeds and the differences between sister families become smaller.

BACK-CROSS METHOD

This technique has great use in a breeding programme when a single gene which is inherited in simple Mendelian fashion needs to be incorporated in a popular variety in order to improve a specific character. The method has a good chance of producing the desired genotype, and it is possible to conduct back-cross programmes with small numbers of plants and without recourse to very strict selection.

The exact conduct of such a programme will depend on whether a dominant or recessive allele is to be introduced into the variety. Initially a cross is made between the popular variety and a donor genotype which carries the desired allele, and subsequent generations are repeatedly back-crossed with the popular variety which is known as the recurrent parent. If a recessive allele is being introduced from the donor, it is necessary to alternate back-crossing with selfing in order to identify and recover the specific character which is being introduced. Selection is made for the general characteristics of the recurrent parent plus this specific character throughout the programme, and usually four or five back-cross cycles followed by two inbreeding generations are enough to establish the improved form of the original popular variety.

It may take slightly longer with the back-cross method than with the pure-line method to complete a programme, though the former can be speeded up by employing certain modifications which increase the numbers of plants to be grown and the numbers of cross-pollinations to be made. There may be hazards in the method which result from the close linkage of undesirable characters with the specific character introduced from the donor genotype, but in general it is a popular technique for tomato breeders who have to manage with limited glasshouse space.

F1 HYBRID METHOD

This has come into considerable prominence in Britain with the successful establishment of Ware Cross. For each crop of an F1 hybrid variety new seed has to be prepared by cross-pollinating two existing pure breeding varieties. The F1 itself does not breed true and seed should not be saved from such plants. Although F1 seed is usually about twice the price of ordinary seed, it still represents only a fraction of the total cost of crop production.

F1 hybrids can be bred in one generation from existing pure lines, though like all new varieties their potentialities have to be assessed in trials. It may be desired to breed new parents which can be crossed to produce desirable F1 hybrids, and these would have to be selected in pure-line or back-cross programmes. If a desired character is determined by a recessive allele, it must be carried by both seed and pollen parents. If a good combining variety has a desirable character which is determined by a dominant allele, e.g., *Cladosporium* resistance, a range of resistant F1 hybrids can quickly be produced by crossing it with a number of other varieties.

Perhaps the greatest value of F1 hybrid tomatoes is in their role of combining characters, rather than in any expression of heterosis for specific unit characters. For example, the F1 is usually intermediate between its parents for both fruit number per plant and mean fruit weight. By crossing heavy yielding varieties which have low numbers of large, poor quality fruit with lighter yielding varieties which have high numbers of small, good quality fruit, some F1 hybrids can be obtained

which help combine heavy crop with improved fruit quality by producing an average number of fruit with intermediate size.

The method has appeal to the seed companies for they can retain control of the seed-production of their own F1 hybrids by not divulging information of the parental genotypes. For F1 hybrids bred at State institutes, the National Institute of Agricultural Botany operates a certification scheme to ensure purity of the seed.

F2 METHOD

F2 seed is offered by some American seed companies with the claim that certain advantages of the F1 hybrid are retained in the next generation, though the plants are more variable. F2 seed is cheaper than F1 seed and it may have some use for extensive outdoor plantings, but for British glasshouse culture, where the financial investment per plant is high and uniformity is essential, its use is not to be recommended.

MUTATION METHOD

Various types of radiation have been used on crop plants in the hope of inducing useful genetic changes, but as yet no new mutations of direct use for tomato breeding programmes have been produced.

GRAFTING METHOD

Claims for the value of "graft-hybrids" still come from some workers, but the method remains unsubstantiated and unused in most countries.

A grafting method which has aroused great interest is in the use of an interspecific hybrid, *Lycopersicon esculentum* × *L. hirsutum*, as the rootstock with the usual *L. esculentum* fruiting variety as the scion. Available rootstocks already incorporate corky-root and *Didymella* resistance from the wild species, and by the use of certain *L. esculentum* genotypes *Verticillium* or root-knot nematode resistance can be added.

This grafting technique, coupled with the F1 hybrid method, provides a very flexible system, and it is possible that at some time in the future the grower might be offered an F1 hybrid scion featuring *Cladosporium* and tomato mosaic virus resistance, grafted on to an F1 hybrid rootstock which carries resistance to several soil pathogens. To breed a pure line incorporating all these characters, and also to retain earliness, heavy yield and high fruit quality would be a formidable task.

Breeding at the Glasshouse Crops Research Institute

COMPACT PLANT-HABIT

A recent survey⁴ has shown that, in spite of its low quality fruit, Potentate is the most popular variety for early crops on large nurseries. This is possibly related to the intermediate nature of the plant's vegetative habit, which makes it easier for the grower to retain control of his plants with less attention to their culture during the difficult days of December, January, and February. By contrast, many growers who

plant out early on steamed soil reject Ware Cross because of its vigorous growth and tall spreading habit. With the present growing techniques it is difficult to control the plants, and also labour costs for training and trimming are high. At G.C.R.I. considerable attention is being given to the problem of vegetative habit in tomato breeding programmes.

Linked seedling character. Compact habit is controlled by a recessive determinant which is inherited in simple Mendelian fashion and it is either tightly linked or pleiotropic with green stem. By selecting green stem seedlings when pricking out from a segregating family, compact habit plants are recovered. In order to produce compact habit F1 hybrids the genetic determinant must be carried by both seed- and pollen-parents.

Back-cross programmes were initiated in 1956 to transfer compact habit from the variety Baby Lea to fifteen existing commercial varieties including Ailsa Craig, Moneymaker, Potentate, E.S.1, Harbinger, E.S.5, and Vagabond. These programmes have been continued through three or four back-cross cycles, and the new compact habit forms closely resemble their recurrent parents in other characters such as leaf shape, truss size, and fruit quality.

The expression of compact habit varies with the genetic background of each variety. For example, the compact E.S.5 is taller than the compact Harbinger; and this difference is related to the slight habit difference between the original tall spreading forms of these two varieties. Some of the compact habit forms have now been crossed in order to produce F1 hybrids; the compact habit Potentate crossed with the compact habit E.S.1 should give a Ware Cross with compact habit, but the cropping and fruit quality of this material have yet to be assessed.

Trials at Experimental Horticulture Stations. Many of the compact habit forms of both straight varieties and F1 hybrids are being compared in replicated trials at G.C.R.I. and at Experimental Horticulture Stations of the N.A.A.S. in 1961. The corresponding tall spreading forms are also included, and where possible experiments to test varietal interaction with environmental factors have been arranged. At centres with limited space and facilities the varieties have been divided into two groups, comprising compact habit forms and tall spreading habit forms, and these are being grown in separate but comparable glasshouses.

Whilst all the varieties in one group are treated similarly, the two groups are managed individually in order to exploit their potential to the maximum. Final comparisons will then be made between the interaction of one genotype with its optimum environment and the interaction of a second genotype with its optimum environment. Replication for such trials will have to be achieved by repeating trials at different centres or in different years.

New compact habit varieties have also been selected by the pure line method in order to speed up the production of such varieties so that the desirability of compact habit plants could be determined and experience gained on their cultural requirements. From the original cross Baby

Lea \times E.S.5 several lines have been selected to the F8 or F9 generation. All these lines carry green stem and compact habit but they vary in fruit size and fruit quality and have small differences in earliness and total crop weight. This material has been successfully grown by certain growers and Experimental Horticulture Stations for the past two years, and has now been released under numbers GCR2-GCR25 for extended grower trials in 1961.

These compact habit varieties do not represent any great breakthrough in the search for improved fruit quality; the quality is similar to that which is already featured by some existing varieties which have tall spreading habit. What the new varieties do is to make this better fruit quality available to a larger number of growers, by combining it with the more vegetatively restricted compact habit to give the type of plant that certain growers like to manage. At present, the compact habit varieties are only recommended for use on steam sterilized soils. In the correct environment they will maintain satisfactory growth, but under adverse soil conditions the plants may become weak as the season progresses.

INTERMEDIATE PLANT-HABIT

Further programmes aim to reproduce the tall spreading varieties with the intermediate habit derived from Potentate. The inheritance of this character is rather more complex than compact habit, and there is no linked seedling character to facilitate selection. Some lines are already combining this vegetative character with the truss type, early ripening and fruit quality of Ailsa Craig. The variety E.S.1 is also being modified so that it will have the habit of Potentate. By crossing this with Potentate itself, the F1 hybrid Ware Cross in a form with intermediate habit should be produced.

FRUIT COLOUR

Serious reduction in fruit quality often occurs in mid-summer because of the high incidence of the disorders known as green-back, yellow-back, or hard-top. Most varieties are prone to this trouble though it can be eliminated genetically, as in the varieties Stonor's Moneymaker and Exhibition, by the introduction of the simply inherited character, uniform ripening. The recessive allele which determines uniform ripening is being transferred by the back-cross breeding method into several other varieties. With Potentate and Ailsa Craig three back-cross cycles have been completed; the families are already very uniform, and plants have the vegetative habit, truss type, fruit size and shape of the recurrent parents plus freedom from green-back.

Moneymaker is a popular variety because of its freedom from green-back, but it is often criticized as being a variety whose fruit is slow to turn colour after it has reached full size. This may be a side effect of the allele which determines uniform ripening, or it may be due to some other determinant in the Moneymaker genotype. The issue may be

clarified by comparing the maturing time of the original Ailsa Craig and Potentate with the new uniform ripening forms of these two varieties.

The uniform ripening allele eliminates green-back, but fruit are still liable to suffer from other ripening disorders which result in uneven coloration. The incidence of blotchy ripening may be related to fruit size, for the smaller fruited varieties generally have a higher percentage of uniformly red fruit than do larger fruited varieties. This can be very well demonstrated by growing the following species and varieties—*Lycopersicon pimpinellifolium*, *L. cerasiforme*, Harbinger, Ailsa Craig, Potentate, and Marglobe, a very large fruited American variety. The optimum fruit size for financial return is when they weigh 8–12 per lb so, if heavy crop yields are to be achieved with this average size, each plant must carry many more fruit than Potentate, for example, which may average 5–6 per lb. Such an improvement could be attempted by increasing the number of trusses per plant, or the numbers of flowers and fruit per truss.

The character "compound inflorescence" is being examined, for on a plant with this genotype the trusses may have 250 flowers and often set up to 200 fruit. It is determined by a recessive allele which is being transferred in a back-cross programme to the variety Ailsa Craig. The wild stock which served as the donor parent also had a small beak at the stylar end of each fruit, and so far it has not been possible to eliminate this. It is hoped that further back-crosses will lead to plants combining compound inflorescence and perfectly round fruit of the optimum size.

DISEASE RESISTANCE

Attention is now being given to disease resistance both in breeding programmes and by use of the grafting technique.

No genotypes which confer true resistance to tomato mosaic virus are known, but various stocks which behave as symptomless carriers are available. The expression of tolerance may vary with different strains of the virus, but its inheritance is being studied with a view to its incorporation in commercially acceptable varieties.

Material from the John Innes Institute is being used to develop a range of *Cladosporium* resistant varieties. Dominant alleles which confer resistance have been transferred by the back-cross method to certain existing varieties, and these can now be used for the production of F1 hybrids.

Possible developments of the grafting method are being sought with investigations on the technique, alternative genotypes for the rootstock, and the use of compact habit scions on strong growing roots.

The Future

The formula for the perfect tomato has not yet been described, and the breeding of the necessary genotype may be an unattainable objective, but the future holds an increasing wealth of material. Perhaps some of the most promising varieties will come by combining genotypes which

have been produced quite recently. It should soon be possible to present the popular F1 hybrid Ware Cross with three different habits, all incorporating leaf mould resistance, freedom from green-back and seedling markers to detect contaminants.

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Some Thoughts on the Control of *Agropyron repens* by Herbicides

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WEED CONTROL is due to reach a turning point in its development. By good fortune the discovery of the substituted phenoxyacetic acids produced a group of herbicides which has become enormously successful. They are successful because they do the job for which they are recommended. Widespread laboratory, greenhouse and field work quickly produced information on dose rates, time of spraying in relation to the stage of growth of the crop and weed, and environmental limitations. This information has subsequently been found to hold true in a very wide range of circumstances. As a consequence of this near certainty of action of the herbicides, they were widely accepted into agricultural practice. Judged by any standards, there are few other herbicides that have fulfilled their early promise to the same extent.

Many herbicides are known, and they are diverse not only in their structure but also in their selective potential. The word potential must be emphasized for it represents the crux of most problems associated with the control of perennial weeds. There are circumstances when all herbicides which have reached the market and have been advertised for a particular purpose, will fulfil their promise. The potential is there, but in the field it is frequently realized only spasmodically. It is probably fair to argue that for every important weed of British agriculture there are one or more herbicides which at some time have effected a complete kill of that weed. The problem then is one of variability and this article will examine some of the possible causes of variation when a systemic herbicide is applied to *Agropyron repens*.

Sources of Variation

Variation in the response of a weed to a herbicide can spring from two main sources. Either the weed itself is inherently variable in its response to the chemical from site to site, year to year or even day to day or environmental conditions affect the success of the application either directly or indirectly. These two potential sources of variation we may term inherent and environmental, respectively.

(A) ENVIRONMENTAL VARIATION

The majority, if not all, herbicides act at cell level and when a chemical is applied to foliage there are three important steps necessary before the substance reaches its site of action. The familiar processes are described as retention, penetration, and translocation. Both the nature and extent of the leaf surface determine the quantity of spray that foliage will retain, although this can be influenced by changes in the properties of the spray solution. The time interval between application and penetration is, however, a crucial one, for during this phase the chemical is liable to be washed off the leaf by heavy rainfall, or to be immobilized by a rapid drying up of the droplet in conditions of low humidity. We shall return later to the question of translocation.

(B) INHERENT VARIATION

To gain an understanding of the potential reason for inherent variation, it is essential to understand something of the biology of the weed under study.

Here *Agropyron repens* is a suitable material for argument, for the growth cycle of this species has been studied in some detail. Working with an undisturbed stand of the weed, Palmer¹ described how the plant overwinters above ground as an aerial shoot with 1-2 leaves formed as a result of the erection of rhizome apices. In mild winters the plant undoubtedly continues growth but renewed activity begins in the spring when the main shoot begins to grow vigorously, adding new leaves and subsequently tillers. Following the initiation of tillers, buds lower down on the shoot axis begin to grow out as rhizomes. The latter, a familiar sight to a vast number of people, have potential in many directions. Under undisturbed conditions, where interference from other species is minimized, each rhizome grows horizontally through the soil and may attain a length of 2 metres in a single growing season. In addition rhizome branching occurs in July under these ideal conditions, and Palmer has estimated that as many as 50 rhizomes may be produced from a single shoot in one growing season. This potential points to a weed which will be successful in arable land, for vegetative reproduction on this scale is an effective means of dispersal. However this is by no means the limit, for each rhizome bears along its length, at intervals of about 0.5-6.0 cm., scale leaves with buds in their axils. Some of these by the end of the season have grown out as lateral rhizomes but others remain dormant practically indefinitely in the undisturbed stand.

Regeneration System

Disturbance of the intact rhizome system, as a result of cultivations or other damage promotes the growth of the dormant buds. These develop as aerial shoots, produce tillers and new rhizome systems and behave similarly to the overwintering shoots. There is, however, one important difference. Cultivation can take place at any time and in consequence the developmental cycle of the weed may be displaced seasonally. Tiller and rhizome formation may occur for example in early autumn following stubble ploughing.

This regeneration system can result in the spread of the weed over a wide area from a localized outbreak as a result of the adhesion of viable fragments of rhizome to machinery or as a result of harrowing. However, this regenerative power has been turned to advantage recently (see Fail² and Proctor³). Although there are a large number of dormant buds on a rhizome system this number is finite and if each source of potential regeneration is destroyed the weed will ultimately be incapable of regeneration.

No really critical experiments have been made to determine the biological reasons for the success of rotary cultivation as a means of control. Undoubtedly the rotary action seriously disturbs the rhizome system and results in fragmentation. Some, and on rare occasions all, dormant buds on each fragment then grow out to produce aerial shoots which are seriously damaged if not killed by a second cultivation. Repetition of this process ultimately results in the loss of all dormant rhizome buds and hence the power of regeneration. Several aspects of this subject require investigation. It is not clear how far rotary cultivation results in the depletion of the food reserves of the rhizome system rather than the loss of dormant buds; nor is it clear how far the severing of true roots and the "puffy" nature of soil cultivated in this way may play a part in desiccation and death of rhizomes brought up to or near the soil surface.

OTHER BIOLOGICAL FACTORS AFFECTING CONTROL

One other aspect of the work of Palmer (*loc. cit.*) deserves comment. *Agropyron repens* will not produce new rhizomes when the light intensity falls below a value of 5-7 per cent of full summer daylight. Under such circumstances new potential for regeneration is not formed and vegetative spread stops. Thus a good cover of kale might be expected to check the spread of the weed. Taken further, the argument would also suggest that the vigour of the parent plant of *A. repens* determines the degree of vegetative spread. This is well demonstrated by an examination of any stand of *A. repens* which has not been disturbed for 3-4 years. The annual production is no longer 30-40 rhizomes, the principal ones 1-2 mm long, but 1 rhizome 5-10 cm long. This would suggest in turn that an infestation of *A. repens* might most readily be checked by the introduction of a vigorous ley when such was

economically possible. *A. repens* is notoriously sensitive to close cutting and to grazing if the animal is not a selective feeder.

Behaviour of Rhizomes

These then are the biological factors which operate when cultural methods of control are used. There remains but one *idea* to be outlined. The behaviour of rhizomes presents a fascinating problem. Not only do the majority of the buds on the rhizomes remain dormant, but also the rhizome tip grows horizontally a few centimetres below the soil surface for a finite length of time and then rapidly becomes erect, changing during this period from a sharp pointed underground apex to a leafy aerial shoot.

The mechanisms ensuring dormancy and horizontal growth are not understood but the latter depends on the maintenance of active growth by the parent shoot; for if that shoot is destroyed or reduced in vigour by shading, the rhizome tip becomes erect and forms an aerial shoot. This would suggest that the aerial shoot might pass a chemical substance down from the leaves to the rhizome tip. If such a hormone exists, if it can be isolated and if it is economically possible to manufacture it, then here is a superb method of weed control. Such a chemical, applied to the foliage, might be expected to ensure that the rhizome tip never became erect and thus the plant would fail to complete its life cycle.

To return from speculation, there is a most serious question pertaining to the movement of substances along rhizome systems. The annual growth cycle of *A. repens* has been outlined already but it is relevant to think of longer periods of time. When a rhizome tip erects to form the overwintering shoot, the parent shoot dies. In the following summer, apart from the familiar behaviour of the new shoot in producing rhizomes, the old parent might produce an odd shoot; but, most important, the rhizome connection between parent and daughter does not disappear; nor does a rhizome disappear under stable conditions until 2-3 years after its formation.

During this period the buds are a reserve of potential for regeneration, for although they normally remain dormant, damage to the intact system releases the dormancy.

Translocation of Herbicides

Let us consider some of the broad physiological problems involved in translocation in such a system. No matter which view of phloem transport is considered, it is clear that metabolites move from sites of production or storage to sinks* where metabolism is occurring. In an undisturbed system of *A. repens* the potential sinks include root

* "Sink"—a region where metabolites are currently being used or stored.

and rhizome apices, rhizome buds which are being formed or those which are re-activated before growing out as rhizome laterals, storage tissues, aerial apices, expanding leaves, and at the time of flowering and fruiting, the inflorescence structures.

It seems a reasonable assumption that when a translocated herbicide is applied to the foliage of such a plant system it will move in that system in a manner related to the main mass of the assimilates. Even under a system of phloem transport such as that of Kursanov⁴ a foreign material must utilize a system closely allied to one already utilized by existing metabolites. Following this argument, it is unlikely that a herbicide applied to the foliage of a perennial plant will move to dormant buds, or to those parts of a rhizome system which are not directly in line between the source and an active sink.

If this reasoning is correct, then rhizomes which are no longer bearing active tips or aerial shoots are only likely to import via the translocation pathways leading to the tips of roots, which occur at each node on a living rhizome. It is not known how physiologically active these roots remain and in consequence no assessment can be made of their importing potential. It would seem likely however that the roots and buds on older rhizomes would draw on the storage tissues immediately surrounding their points of attachment and not on the assimilates currently produced by aerial shoots some distance away.

If this hypothesis holds, and only experiment will test it, then the mere application of a herbicide to the aerial parts of a plant with an extensive underground system will not always be sufficient to effect useful control. Various possibilities exist to overcome these difficulties. If the rhizome system of *A. repens* remains intact after an application of herbicide has killed the aerial portions and the rhizome apices, dormant buds might be expected to grow out in much the same manner as occurs when the active organs are destroyed by other means. Thus the developing buds might be expected to become strong sinks for any herbicide still present in the system if these buds draw on the full extent of the system during their development and not only on the storage in their immediate locality.

THE TIMING OF CULTIVATIONS

Looking to the other end of the control system, it seems possible that cultivations prior to spraying might be more successful. Ploughing or, more ideally, rotary cultivation, would have the effect of breaking up the rhizome system into pieces. Each of the pieces would produce one or more aerial shoots and no pieces of rhizome would be more than a few centimetres from a shoot which would receive a dose of the herbicide. Translocation difficulties would thereby be reduced. In addition the nodes on the fragments which retain dormant buds would renew their root systems thereby providing some form of sink, however slight, close to each point of potential regeneration.

A technique of prior cultivation followed by spraying the regrowth seems to offer the most likely chance of success but it also raises other problems. During the early stages of regrowth, metabolites will move from storage regions in the rhizomes to regions of active metabolism. These will be root tips, stem apices and young expanding leaves. The pattern of movement of substances in the phloem system will be dominantly if not exclusively upwards. The application of a herbicide to the foliage could not be expected to result in rapid downward movement.

Subsequently, the development of tillers occurs and during this process photosynthates would be moving dominantly downwards to soil level and then up into the developing tillers. Again during this phase, little herbicide would be expected to move down below ground. Following the initiation of tillers, however, new rhizome production commences and at this stage metabolites are moving dominantly downwards to sinks below ground level. At a later stage inflorescences are formed and if *A. repens* behaves in a similar manner to the cereals, the main direction of movement of metabolites is to the inflorescence and the developing grains. It would appear therefore that the best stage at which to spray regrowth would be at the time when new rhizomes are being initiated.

FURTHER FACTORS

The argument so far developed depends on the hypothesis that movement of metabolites and herbicides are closely connected. Crafts⁵ has developed this argument over a considerable number of years. However, evidence has accumulated recently (Crafts and Foy,⁶ Radwan, Stocking and Currier,⁷ Sagar⁸) that some herbicides (Amitrol, 2,4-D and dalapon) may transfer readily from the phloem to the xylem system and if this proves to be so, then an extra factor must be considered. It seems doubtful if, in the British climate, the movement of water in xylem is frequently, if ever, downwards although there are circumstances when this might occur. Thus, the movement of a herbicide to below-ground regions must be dominantly in the phloem and all the factors that have been discussed must still be considered.

However, if there is a loss of a herbicide from the phloem to the xylem, it seems reasonable to suggest that this might be a simple diffusion process and as such might be expected to depend on the relative concentrations of the chemical in the xylem and the phloem. In consequence, the rate of movement of water in the xylem would govern, partially at least, the rate of transference. Under conditions where the transpiration rate was high, e.g., low humidity, stomata fully open, and high wind speed, the downward movement of a herbicide which was transferable from phloem to xylem would be less than under conditions where the transpiration rate was minimal when the movement of the same herbicide would be governed to a greater extent by its passage in the phloem.

Relationship between Biology and Control of Weed

It would be misleading to complete this story without certain general comments on it. Much of what has been written is pure hypothesis, and not very original hypothesis at that, since Crafts developed some of the reasoning and indeed demonstrated its applicability in relation to 2,4-D and wild morning glory. *Agropyron repens*, however, has other specialized problems associated with its control and, if this essay has served to direct a little attention to the relationship between the biology of a weed and its control, then it has served its purpose. *A. repens* is not the only perennial plant which gives variable results following attempts to control it with herbicides, and it is the author's view that a serious consideration of control in terms of a plant's general biology will always be worth while. When any herbicide has at any time killed an important weed and subsequently fails to repeat this success, then our primary object should be to understand the reasons for the variability rather than to condemn the herbicide.

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Malformation of Cereals caused by Growth Regulator Herbicides

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THE GROWTH regulator herbicides MCPA, MCPB, 2,4-D, 2,4-DB, mecoprop, decoprop (2,4-DP) and MCPA/2,3,6-TBA when applied at the correct dose and at the time when the crop is at the correct stage of

growth, cause no malformation of cereals. The stages of growth of cereals at which herbicides may be applied safely are given in the Weed Control Handbook.¹

Ear or leaf deformity can result from spraying some herbicides too early, and ear development may be affected by spraying too late. Malformation of the ear due to early spraying is not necessarily correlated with yield reduction. In 14 experiments on spring barley carried out by the N.A.A.S. over 4 years² low doses of MCPA applied before the crop had reached the five-leaf stage produced occasional mild ear deformity, and the crop yields and the degree of weed control were better than after normal spraying.

Spraying later than the recommended safe stage should be avoided because an appreciable reduction in yield may be caused.

Types of Deformity

Three types of malformation occur:

1. Leaf malformation as a result of spraying early. Application of growth-regulator herbicides during the production of leaf primordia may result in the formation of tubular or "onion" leaves.

2. Ear malformation as a result of spraying early. This takes several forms according to the crop, and their occurrence can vary with possibly the variety, and the dose and type of herbicide used.

BARLEY

- (a) Spikelets opposite each other on the rachis.
- (b) Supernumerary spikelets.
- (c) Bunching of spikelets as whorls round the rachis.
- (d) Abortive spikelets.
- (e) Widened pales and multiple awns, often as a result of the fusion of parts.
- (f) Partially naked grain.
- (g) Twist of rachis through an angle of 90°.
- (h) Extension of internodes on rachis, and weakening of rachis so that part of the ear readily breaks off.
- (i) Twisting or buckling of the stem below the ear. This is generally associated with a tubular uppermost leaf that traps the emerging ear.

WHEAT

- (a) Spikelets opposite each other on the rachis.
- (b) Supernumerary spikelets.
- (c) Bunching of spikelets.
- (d) Enlargement of glumes, often as the result of fusion of parts.
- (e) Splitting of rachis to form branched ears.
- (f) Twisting or buckling of the stem as in barley.

OATS

- (a) Spikelets arising in whorl, not laterally, from a lower node.
- (b) Numerous branches around bottom node and few at the higher nodes.
- (c) Extended or shortened panicles with few branches.
- (d) Spikelets bunched at the end of branches, and sometimes fused and distorted.
- (e) Split panicles.
- (f) Twisting or buckling of the stem as in barley.

NOTE: Some of these symptoms can occur naturally on occasion.

3. Ear blindness as a result of spraying late. Definite symptoms of malformation, such as produced by early spraying, are not associated with late spraying. The most susceptible stage is anthesis and growth regulator herbicides applied at this time can prevent proper grain development.

A check to the crop before anthesis, as the crop is "jointing" (i.e., when nodes can be seen at the base of the shoot) can also lead to badly filled ears. MCPA/2,3,6-TBA is particularly liable to check the crop at this stage and cause the production in wheat and barley of "rat-tail" ears, often accompanied by blackening from "secondary infection". The effect is very similar to take-all infection which has checked the crop at the same stage.

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Apple Harvesting and Handling

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WORK STUDY investigations of the harvesting and handling of apples have been carried out in various parts of the country over the past three years. Costs show considerable variation, and our studies suggest how improvements can reduce the cost of apple production. Trends in market prices and labour costs make more efficient methods of production imperative, if a reasonable return is to be obtained.

Economic Considerations of Apple Production

Costs can be divided into (a) production costs incurred up to the start of picking, and (b) for picking, storing, and preparing for market.

- (a) Costs for manuring, spraying, pruning, and cultivating, etc. remain much the same per acre regardless of the tonnage produced, and it is the average tonnage of first quality fruit produced per acre which decides the profitability of top fruit growing. The greater the tonnage per acre the less the cost per ton produced up to picking time. For example, if production costs and overheads total about £70 per acre up to the time of picking, a 3 ton crop will cost £23 per ton, a 6 ton crop £12 per ton and a 9 ton crop £8. Savings made in handling and preparing for market never offset completely the effect of low average yields per acre.
- (b) These costs can be calculated for each ton or bushel as it passes through the various processes of picking, storing, grading, packing and marketing. All these processes have been studied in considerable detail both here and in other apple growing countries. A high standard of technical skill to produce high yields, allied with the best of modern handling and packing techniques, results in low handling costs.

Orchard Layout and the Economics of Production

Given an equal standard of soil and technical management, the yield of first quality apples is closely related to the amount of well-lighted bearing wood that can be accommodated on each acre of land. Limiting factors are the light requirement of the crop, and the necessity for reasonable access to the trees.

For the small orchard, high yields from close planting are necessary to spread overhead costs over the largest possible tonnage of fruit, even if there is some increase in picking and handling costs. For the large orchard, easier access is essential if harvesting is to be completed in

reasonable time without the use of great numbers of pickers who today are generally not available. Overhead costs for machinery and buildings will normally be considerably lower per ton with larger scale operations.

In recent years, the need to apply sprays immediately before picking on all fruit for storage has required more access room. Hedgerow methods with intensive or semi-intensive systems have increased in popularity, and a similar type of plant using fairly upright rather than spreading trees appears to be the most likely to meet future requirements. With large spreading trees a considerable non-fruit bearing area can occur within the tree itself. A minimum clearance of 4 ft. between rows at picking time should be sufficient to allow late spraying and easy handling.

In some cases square plants are becoming overcrowded for fruit handling, particularly the extraction of early ripening pollinator fruits, but spraying is still possible. In these circumstances, the removal of every fifth or seventh row at right-angles to the pollinator rows will allow a high density of trees to be maintained and provide easy carting access to each 4 or 6 row block.

Fruit Handling

These operations absorb a great deal more labour than pre-picking activities and therefore are more likely to show savings due to properly applied work study investigation. Picking, box or bin handling, grading, and packing can be studied in detail and the easiest and cheapest method arrived at for any particular set of circumstances. It should always be remembered that each stage adds to the cost of the fruit, and that careless handling will cause damage and subsequent deterioration, so that speed of handling is not the only requirement.

PICKING FRUIT FROM THE TREE

Careful training of pickers is essential. Both hands should be used simultaneously whenever possible and the fruit should be placed, not dropped, into the picking container. Speed of picking varies with tree size and crop density, and will vary from year to year. The main requirement is a system that allows the highest possible percentage of time to be spent on picking as compared with walking, emptying, and step and ladder moving.

Picking from the ground in the systems studied showed 73 per cent to 82 per cent actual picking time with 18 per cent to 27 per cent walking and emptying time. Picking from steps and ladders decreases the percentage picking time as the size of steps or ladders increases; using 10 ft steps it was generally about 60 per cent. From the few cases studied involving ladder picking, the time spent actually picking ranged from 40 per cent to 50 per cent. Very spreading trees are almost as difficult to pick as tall trees, while heavy top crops which can be reached from 8 ft steps can be picked almost as quickly as from the ground. Light top

crops requiring 10 ft steps or ladders are the most expensive to pick. Controlling the trees so that all picking is done from ground level may reduce the total crop per acre and raise the cost per ton produced in spite of the lower picking costs. The best possibility for heavy crops appears to be well furnished but not greatly spreading trees that do not require the use of anything larger than 8 ft steps for harvesting.

WALKING

Walking can be reduced, by positioning boxes or bins as near as possible to the trees being picked, and, secondly, by increasing the size of the load that can be comfortably carried during picking. Picking bags or aprons with two shoulder straps give a better distribution of weight over the body, and have about twice the carrying capacity of smaller picking hods with a single shoulder strap. Whatever picking container is used it should be maintained in good condition, as poor straps lead to underfilling and defective fastenings to hold-ups and damaged fruit. Substituting picking bags or aprons for small hods will shorten the picking time by 5 per cent to 10 per cent. These picking bags are particularly suitable for use in conjunction with bulk bins.

Bags should be adjustable for size as male pickers often prefer a larger load. Picking containers other than those that are attached to the body generally give slower picking times, as either the hands have further to travel to reach the container with each lot of apples, or one hand is used to hold the container and one for picking.

Picking from the ground direct into boxes to save emptying damage is generally slightly slower than picking into hods or bags, but much depends on the height of the box during picking. The use of light-weight stands to position the box hand high is well worth while. If non-returnable wooden boxes are used in this way there is a saving in handling empties in the packhouse during grading. With heavy crops a 30 lb box will reduce the walking time but with a light crop the need to re-position the box frequently will outweigh this advantage.

EMPTYING

This is one of the most frequent causes of bruising in the orchard. The use of small boxes raises the time required for emptying. Bulk bins generally give an 8–10 per cent saving in picking time owing to easier emptying of the picking containers, and by eliminating the need to set out boxes before emptying and to change over boxes during emptying.

BOX OR BIN HANDLING

The choice of box handling methods is controlled by two factors:

- (i) the volume of fruit to be handled each year, which will decide what degree of mechanization is economically justified; and
- (ii) the position of the orchards in relation to the stores and packhouse, which will decide the most economic method of transport.

Manual handling of individual boxes at every stage is the most expensive method and the most likely to cause bruising, particularly when high stacking is involved. To reduce costs in any problem of this type, the handling of the individual boxes must be reduced to a minimum, either by the use of pallets from the picking point onwards or by the use of bulk bins.

The extent to which a fully mechanized system can be used economically will depend on the size of the average crop when the holding is fully developed. From the studies completed, a crop of 300 tons per annum is probably the minimum for mechanical handling. However, taking into account the increasing cost of labour, the use of cheaper equipment and smaller pallets which require less lifting power make the use of mechanical handling on crops of between 200 and 300 tons an economic proposition. On an even smaller scale the use of pallets to avoid much individual box handling is still well worth while, although high stacking will probably have to be completed by hand. The great saving in physical effort achieved with even limited mechanization should not be overlooked.

Any system must be carefully planned if it is to work efficiently, and much thought should be given to the size and type of boxes and pallets to be used and the lifting equipment employed before any capital is spent. More particularly, all packhouse and storage buildings being erected on holdings likely to produce over 100 to 150 tons per annum should be planned for mechanical handling, as various forms of mechanization will almost certainly be universal before such buildings have completed their useful life.

Stages in Mechanization

FROM THE TREE TO THE EDGE OF THE ORCHARD OR THE PACKHOUSE

This system can be used for both the collection of filled boxes and the distribution of empties. The equipment is reasonably priced and it can be used on any size of holding by duplicating the equipment according to the rate of collection required. Pallets are distributed with the empty boxes, preferably of a size to give a full load of 8–14 cwt according to the capacity of the tractor available. The tractor is fitted with pallet forks on the 3-point hydraulic linkage, and provided with front weights and booster ram if required. As long as the average journey from orchard to packhouse does not exceed half a mile and a 10 cwt load is carried, this is the cheapest and easiest system to operate.

Filled boxes are stacked on the pallets by the pickers or the supervisor and all pallets are picked up and put down at ground level. For longer journeys a tractor fitted with pallet forks on a rear or fore-mounted loader can be used to extract the pallets from the orchard and place them on a trailer. For large scale operations a shuttle service of trailers to keep the loading tractor fully employed is preferable. For



Variety: Delicious. C46 - Compact habit. B758 - Tall spreading habit. Similar in truss type and fruit size.



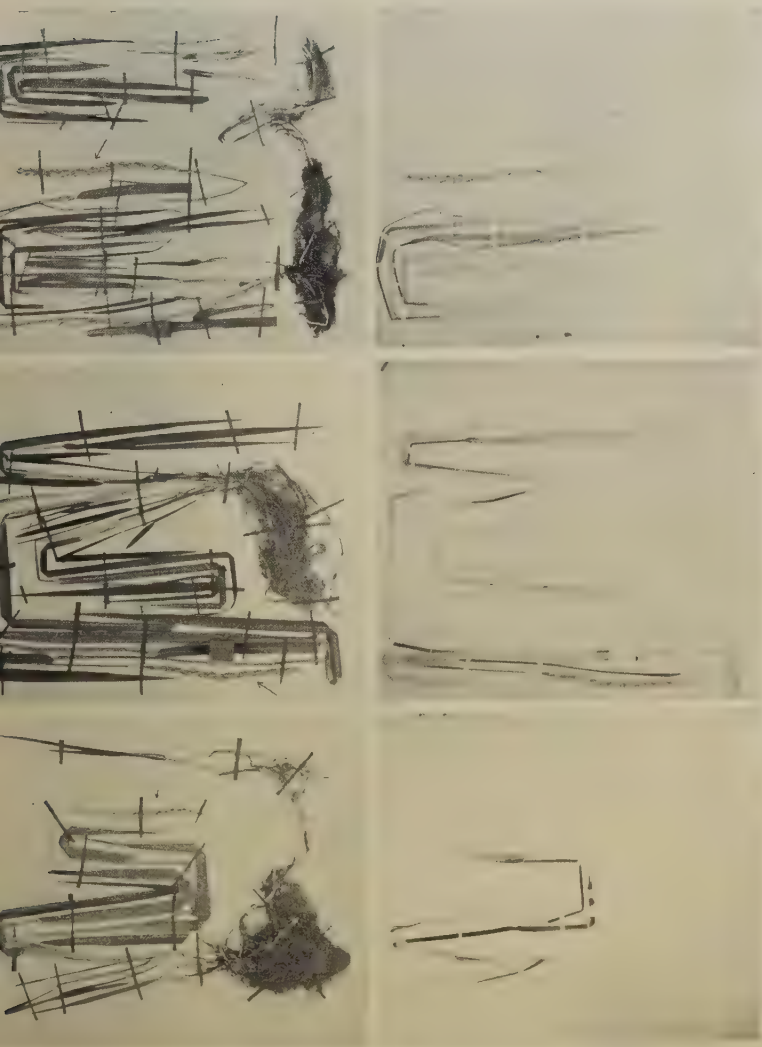
Variety: Ailsa Craig. C6 - Prone to green-back. B738 - Free from green-back. Both with tall spreading habit and similar in truss and fruit characteristics.



A grafted tomato plant with the scion still growing on both its own root and on the interspecific F₁ hybrid root-stock.



A trial of new compact habit GCR tomato varieties.



Autoradiographs (lower) of the plant material (upper) show the distribution of C-14 labelled dalapon fed as a drop on a single leaf. The dalapon was allowed to translocate for 3, 10 and 17 days (L to R) before harvest. Note how the dalapon moves slowly and accumulates in the inflorescence rather than in the below ground organs.



Arrangement of material and dalapon treatment as in Plate III. (Left) no extra treatment; (centre) light excluded from the treated shoot; (right) both shoots covered by transparent shades. All are 10 day treatments. Note the marked effect of extra treatments on the distribution of the dalapon. In both plates the treatment spot is covered by masking tape (see upper series).



Abnormal ears of wheat showing supernumerary spikelets,
opposite spikelets and enlarged glumes



Abnormal ears of barley showing whorled spike-
lets and 90° turn of rachis.



Abnormal ears of barley showing whorled spikelets and extended internodes of rachis.



Abnormal ears of barley showing tubular leaf trapping emerging ear and kinking of the stem, and aborted spikelets.



Abnormal heads of oats showing contraction of panicles, many spikelet stems arising from the lower node, leaf partly enclosing panicle, kinking and twisting of the stem, and aborted spikelets.



Left: failure of ears of wheat to fill properly after late spraying.
Right: normal.



[Photo : National Institute of Agricultural Engineering
Automatic watering of cucumbers.]

smaller scale operations, a trailer that can be loaded while standing without a tractor, and a loader that will allow a trailer to be easily hitched and towed, will make collection a one-man operation.

For mechanical loading, trailers must be flat topped and the wheels should not project above the level or outside the bed. Two wheels either side mounted in tandem or double wheels will help prevent bruising when travelling over rough ground. Rates of collection with these methods will vary with distance and load size but between 100–200 bushels per hour will be obtained with one operator.

Where trailers are to be loaded mechanically at the edge of the orchard, a clear area 40–50 ft square will be required. Hardening of the surface with stone or clinker will be advisable if the same area is to be used for a prolonged period. Where bins are used instead of boxes the same systems can be used. Specially fitted tractors can transport 3 bins or 2 pallets on each journey, but care is necessary to avoid overloading on the front axle, particularly on rough ground.

UNLOADING AND STACKING IN STORE

Where pallets or bins are carried on the tractor they can be put down wherever required. If full scale mechanical handling is not justified the stillages or pallets can be handled by special hand trucks or a hand operated stacker.

The type of pallet or stillage to be used must be carefully considered when designing the handling system. The size of pallet must accurately fit the boxes in use when they are stacked as unit loads. Whenever possible the pallet should also be interchangeable with one of the recommended standard sizes of bulk bins. To facilitate complete mechanical handling and stacking, the design of any future cold store should be related to the size of either the pallets or bins.

If the fruit is to be graded immediately, the boxes should remain on the pallets until they are removed for tipping to the grader. For storage where no lifting equipment is available the bottom layer should be positioned and left on the pallets and the upper layers hand stacked. This system merely replaces the usual slatted floor with a layer of pallets and still allows maximum store capacity. Using this method the number of pallets required is considerably reduced when compared to a fully mechanized system, although the labour cost will be higher. Bulk bins cannot be lifted by hand when filled and, wherever they are to be used for storage, mechanical stacking is essential.

Where pallets or bins are brought to the packhouse on trailers three systems of unloading are possible:

- (i) lifting off with a fork lift truck or mobile stacker;
- (ii) unloading with a hand pallet truck at an unloading dock or raised platform;
- (iii) fitting roller conveyors to the floor of the trailer and pushing off on to suitably arranged roller conveyors at the packhouse.

The first requires a concreted or asphalted area about 40 ft square and strong enough to withstand the weight of the loaded truck. But variations in trailer or lorry bed height do not matter, and loads can be taken direct from trailer to store or put aside to await future stacking if quick turnround of transport is required.

The second system works best with trailers of standard bed height; the unloading equipment can be duplicated if required and the fork lift truck used only for stacking rather than for horizontal transport.

The third method is very useful for bulk bins when the fruit is to be graded immediately after picking. The roller conveyors are positioned at trailer height and lead direct to the emptying mechanism. They should be sufficiently long to hold about two or more trailer loads of bins so as to avoid hold ups of either graders or pickers.

Any of these systems make unloading a one-man job in less time than it would take two or three men to do it manually; fruit bruising is less and the saving in physical effort is considerable.

Conclusion

All handling is a direct charge on each bushel of fruit produced; small savings in labour cost or fruit bruising at each stage cheapen the overall costs of production, improve quality, and in consequence, the grower is better placed to meet competition. It is the stage by stage examination of the processes between the orchard and the consumer that can lead to savings of cost all along the line. The problem is to find the most economic and suitable method for the particular orchard and to use the maximum amount of mechanical handling that can be economically justified by the through-put. Picking and orchard handling will always remain a fruit grower's problem. Processing for market may be done on the holding or in co-operation with others and the stage by stage examination of these further processes will be continued in another article.

N.A.A.S. horticultural officers have a considerable amount of information on handling systems which would be particularly valuable to growers planning mechanical handling, and detailed times for the systems described are available in the N.A.A.S. work study unit.

ACKNOWLEDGMENT

I should like to thank all the fruit growers and their employees who gave such willing co-operation in a very detailed investigation of their working methods.

The Influence of Grazing Management on Grassland Production

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THE EVALUATION of the effects of different management techniques on livestock production from grassland is notoriously difficult. During the past few years apparently conflicting results have been obtained from separate experiments designed to study this problem. Many different methods of grazing have been advocated, from continuous stocking with gang mowing, through various systems of controlled rotational grazing (including strip grazing with or without a back fence) to mechanical harvesting or zero grazing.

Much of the confusion has probably arisen because there are three separate major factors that determine the amount of livestock production from grassland. These are (1) the quantity, quality, and seasonality of the herbage growth; (2) the proportion of the grass crop which is consumed by livestock; (3) the efficiency of the livestock in converting herbage into animal products.

Defoliation and Herbage Production

A considerable volume of accumulated field data shows that infrequent cutting results in much higher annual yields of herbage than frequent cutting during the same period. As yields increase with longer rest periods, so the quality of herbage drops, and there is an optimum frequency of defoliation at which relatively high yields of good quality herbage can be obtained.

From these results the thesis has been developed that the best management for grassland involves the use of systems that allow intervals of recuperation between short periods of utilization (e.g. rotational grazing). Rest periods of 30–40 days have generally been considered to give the best compromise between yield and quality. Recently Voisin¹ has criticized fixed intervals between grazing, and has emphasized the necessity of varying the rest period with the rapidity with which grass is growing. Thus, under adverse conditions (such as long droughts) when grass growth is reduced, the rest periods should be longer than when conditions are favourable, without prolonging the grazing periods themselves. Areas of grassland previously used for conservation should then be brought into the grazing rotation. Voisin considered that relatively frequent grazing during poor growing conditions would deplete food reserves with a subsequent deterioration in the vigour and productivity of the sward.

Root Reserves

The importance of root reserves in grassland management has been emphasized by many agronomists since the 1930's, and has been used as an additional argument in favour of rotational grazing. Some of the earliest work in this connection indicated that frequent cutting of lucerne depleted carbohydrate reserves in the roots, and this depletion had a marked effect on recovery growth. It was concluded that organic food reserves were manufactured in the herbage and transferred to the roots where they were stored until required for recovery growth after cutting or periods of senescence. The storage of these reserves was essential to normal top and root development, and the quantity and availability limited top growth after defoliation.

The concept that carbohydrates are stored in the roots of plants, and subsequently translocated for herbage recovery growth, has also been assumed for grasses under sward conditions. Thus, research work in South Africa and America has shown that frequent hard defoliation reduces root material, carbohydrate reserves and subsequent herbage growth (Troughton).² It has generally been agreed that the effects of frequent defoliation are cumulative: the more intensive and frequent the defoliation the lower the levels of carbohydrate reserves, and the poorer the subsequent herbage growth.

CARBOHYDRATES

Various recent experiments have, however, indicated that the build-up of carbohydrate reserves may not be as important, particularly in swards under temperate conditions, as previously supposed. Thus, after an extensive review of the appropriate literature, May³ queried the fact that a decrease in the amount or percentage of non-structural carbohydrates necessarily implies a causal role for these reserves in initiating or promoting regrowth. The effect of defoliation on reserve carbohydrates and recovery growth has been studied in Britain, particularly with reference to autumn management and growth the following spring (Baker and Garwood⁴). The only time there was a positive correlation between recovery growth after defoliation and the previous level of soluble carbohydrates occurred during winter when the rate of photosynthesis was low. Once conditions were favourable for active growth there was no such correlation. It is more important to graze ryegrass swards during the autumn to encourage tillering, than to rest them in order to accumulate carbohydrate reserves. The latter treatment produces open swards which are not dense enough for high production the following spring. However, these effects are only transient and are soon masked by subsequent management.

Thus, Mitchell⁵ in New Zealand found that in a perennial ryegrass sward the rate of tillering increased or decreased rapidly according to the environment, and he stressed that the pattern of tissue formation was dependent on current, rather than previous, light and temperature conditions. This work indicates the rapidity with which the grass

plant can adapt itself to environmental conditions. It appears therefore that under favourable growing conditions food reserves in grasses may be of less importance than previously suggested. However, they may still be important for regrowth during periods when the environment limits herbage production.

Leaf Area Index

New ideas on the effects of management on herbage productivity have recently been proposed as a result of studies involving assessments of the leaf area index: the leaf area index (L.A.I.) is the leaf area per unit area of land. Brougham⁶ studied the significance of L.A.I. in relation to the rate of herbage growth under sward conditions in Australia. He showed that, as the L.A.I. of pasture increased after cutting, so did the amount of light intercepted and the rate of growth. A point was eventually reached at which some leaves were shaded by others; when this occurred the growth rate declined.

In a perennial ryegrass sward 95 per cent of the available light energy was intercepted at an L.A.I. of 5, and this gave approximately the highest rate of pasture growth. If the ryegrass sward was cut to 1 in. above ground level the L.A.I. did not reach 5 for 24 days or more. Conversely if the sward was cut at 5 in. the L.A.I. never dropped below 5. Swards which were cut at 5 in. had higher growth rates for 32 days after cutting than swards cut at 1 in. and 3 in. These data support the system of "lax" or lenient rotational grazing in which the sward is never completely defoliated and some green herbage is always left so that active photosynthesis never ceases.

Conflicting evidence has, however, been found at Hurley, where the highest total seasonal yields were obtained by cutting every 8 weeks to 1 in.⁷

Relative Annual Yields of Herbage (Dry-matter from Different Cutting Treatments)

Cutting schedule	To simulate	Percentage index of mean yield of 4 years
A. Cut to 1" every 3-4 days	Continuous sheep grazing	117
B. Cut to 2" every 3-4 days	Continuous cattle grazing	100
C. Rest for 3 weeks, cut progressively during the following week to 3, 2, and finally 1"	Rotational cattle grazing	129
D. Rest for 6 weeks, cut to 1" and again to 1" twice in following fortnight	Strip grazing without a back fence	170
E. Rest for 8 weeks, cut to 1"	Strip grazing with back fence	183
F. Rest for 8 weeks, cut to 3"	Lenient strip grazing	140

After "Grassland Research Institute, Exp. in Progr., 1961, 13; 15-16"

Over a period of 3 years Reid⁸ also found that cutting swards at intervals to a height of 1 in. produced 39–49 per cent more herbage than cutting to a height of 2–2.5 in.

Management and Animal Performance

The above figures suggest that strip-grazing should provide considerably greater productivity than rotational grazing, and this should be better than continuous grazing. However, such marked advantages have not generally been realized under experimental conditions. Thus a review of 15 experiments that compared continuous grazing with various forms of intermittent or controlled grazing showed no overall advantage for the latter.⁹ One reason for the lack of difference in animal output between treatments was the adoption in most experiments of a standard stocking rate. Generally these stocking rates were too low to exploit fully the grassland output on any treatment. Ivins *et al.*¹⁰ have discussed at length the fallacy of such experimental data, and have pointed out that the results from these experiments depend upon striking a correct balance between the grass potential and the animal potential. If the potential animal production is less than that of the grass on the different treatments, the animal performance will be maximal under all treatments and no differences will show. It is therefore necessary to ensure that the animal potential is higher than the grass potential on all treatments in order to show differences in terms of animal performance.

VARYING STOCKING RATES

Recently experiments have been conducted to compare animal performance under different managements at varying stocking rates, and far more conclusive results have been obtained. Thus in New Zealand McMeekan⁹ compared continuous grazing with rotational grazing at high and low levels of stocking (1½ and 1 dairy cow per acre). Higher livestock yields per acre were obtained from rotational than from continuous grazing. The differences between the two systems were greatest at the highest stocking rate. Foot and Line¹¹ studied the output of dairy cows which were strip or rotationally grazed at two levels of stocking. There was very little difference in output between the two systems. However, 13 per cent greater production per acre was obtained at the higher stocking rate, although the yield per cow decreased by 7 per cent.

The above evidence suggests that the greater herbage production from controlled grazing systems can only be efficiently utilized by the use of high stocking rates. As the stocking rate increases production per animal may fall, but because of higher numbers the total animal production per acre will rise. Of course, a point will eventually be reached where the stocking rate is so high that the individual animals suffer unduly through lack of nutrition and overall production may fall.

ZERO-GRAZING

Many experiments have been carried out recently to compare the output of zero-grazing systems with normal grazing. Several of these were reported at the Eighth International Grassland Congress.¹² Once again most of the comparisons were carried out at fixed levels of stocking and there were no clear cut distinctions in yield per acre. Yields per animal were generally lower under zero-grazing, possibly because of reduced opportunity for herbage selection. However, more animals were carried per unit area so that total yields per acre were similar. Zero-grazing appeared most successful during periods of grass shortage.

It appears that at low stocking rates the system of grazing management is relatively unimportant if the animals have access to enough herbage of a sufficiently high nutritive value, either by allowing sufficient herbage of variable quality for animals to select from, or by integrating cutting with grazing to maintain sward quality. A good example of the latter is the practice of continuous grazing with sheep and cattle plus periodic gang-mowing (Chippendale and Merricks¹³). As the stocking rate increases, however, it becomes more important to adopt controlled systems of rotational grazing which will result in the higher yields of herbage necessary to realize the increased animal potential.

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Automation in Horticulture

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ALTHOUGH IT IS generally known that a considerable degree of automation is applied in the manufacturing industries such as those producing motor vehicles and domestic appliances, it is not always appreciated that automation is widely employed in some branches of horticulture. But because of the multiplicity and short duration of many jobs, automation cannot be applied as intensively as in those industries employing mass production techniques. Although little automation was used in horticulture prior to 1945 it is interesting to note that Fawkes¹ devotes two pages of his book published in 1883 to automatic temperature warning systems very similar to those used by glasshouse growers at present.

Definitions. The term "automation" is frequently used with different meanings in different industries and even by various people in the same industry. Although definitions of automation exist these are complex and in order to avoid misunderstanding the word automation as used in this article is defined as "The means of automatically performing the required operation with self-acting and self-controlling equipment". Thus a fully automatic system is built up of two principal components, that which does the work and that which controls the operation. In many cases equipment is installed to perform an operation which was previously carried out manually but with the retention of hand control. This is often referred to as automation but in fact it is really mechanization. As a simple example, the change from hand watering to any system of fixed pipe watering, trickle, low level, etc., can be considered as mechanization while the addition of automatic control of when and how much water to apply results in automation.

Manual Control and Automatic Control

With manual control eyes are frequently used to detect a condition, the brain compares this with a predetermined requirement while hands or feet perform any corrective action necessary, the whole being linked by the nervous system. An automatic control system is very similar and can be conveniently divided into three parts:

- (i) the automatic controller, e.g., thermostat, level switch, etc., which detects the existing condition, compares it with a pre-set condition and decides whether or not any action is needed;
- (ii) the regulating unit which operates at the command of the controller and initiates the necessary action to maintain the desired condition;

- (iii) the transfer system which links the controller with the regulating unit. Although various systems can be employed, electrical control is the most suitable and is almost universally employed in horticulture.

The principal, although not the only, advantage of the introduction of automation in the manufacturing industries is the saving in labour which results. In these industries Woollard² estimates on average a saving of $5\frac{1}{2}$ to 1. While saving of labour is of great importance in the horticultural industry, production of better growing conditions, resulting in better crops, is often of equal or greater importance.

GLASSHOUSE HEATING SYSTEMS

It has already been shown that automation can be divided into two parts, mechanization and automatic control, and in general, mechanization is principally responsible for savings in labour while automatic control provides more accurate control of conditions. Thus in the modernization of a glasshouse heating system the replacement of hand-firing by mechanical firing largely contributes to the total saving in labour, while in a well designed system the control part of full automation ensures accurate control of growing conditions. Mechanization and automatic control together result in increased efficiency of fuel utilization. Except in the very largest nurseries frequent manual adjustment of the heating system is not economically justified, particularly during the night period, and is not carried out.

Thus while there will be a saving in labour on small and medium sized nurseries as a result of changing from manual to automatic temperature control, the value of this will be small compared with the improvement in growing conditions and increased thermal efficiency. However, there are cases where labour saving is the principal gain from automation such as the use of the automatic steaming grid³ which can reduce the labour requirement by about 50 per cent.

NEW TECHNIQUES POSSIBLE

Automation has made techniques possible which previously were completely uneconomical with manual control. Mist propagation⁴ in which a film of water is automatically maintained on the foliage of cuttings without excessive water application is an example. With this system shading of the cuttings to keep them cool and reduce water loss is unnecessary, hence maximum benefit can be obtained from available natural light. A further development in the automation of propagation is the automatic reduction of water application near the end of the propagation period with so-called weaning units, so that the rooted cuttings can acclimatize themselves to the naturally drier conditions which they will encounter on being planted out.

Automation Maintains Closer Control

In many cases good automation will maintain closer control of the condition to the desired value than could be obtained in practice with manual control. Three reasons for this, one or more of which may apply, are as follows:

(i) *The absence or distraction of the operator at the critical period.* While at present it is necessary to provide labour purely to control some machines such as tractors, in many cases the worker has to control and at the same time perform other tasks. Thus at the moment when control action should be taken the worker may be involved in other duties with a result that the necessary action is delayed.

A good example of this is afforded by a large nursery employing a stoker to look after the boilers and adjust, once per hour, the heat input to various glasshouse blocks to maintain the correct temperature. Thermograph records have shown that even with much more frequent attention than is given on the majority of nurseries glasshouse air temperatures can fluctuate by as much as $\pm 4^{\circ}\text{F}$ from the desired value under some weather conditions. Under similar conditions with automatic control of the same type of heating system the temperature variation in time can be reduced to $\pm 1\frac{1}{2}^{\circ}\text{F}$.

(ii) *The lack of skill and sometimes interest of the worker in the job.* With the attractions of high wages in other industries, growers in or near industrial areas have to employ semi-skilled or unskilled labour which is not always interested in the job. An attempt was made to improve the standard of watering on a large nursery suffering under such difficulties and employing hand watering by fitting a water meter in each glasshouse unit. Each worker was told the quantity of water to apply, which could be checked by the water meter reading, but it was soon realized that unless careful supervision was maintained a worker who was behind with other jobs could save time by quickly damping the surface where required and then allowing the hose to discharge at a few points until the correct meter reading was obtained. Fully automatic watering would not only overcome this but it would also take the guesswork out of the estimation of the amount to be applied.

(iii) *The inability of workers to detect subtle changes in conditions such as light intensity.* On units employing large numbers of artificial lights electricity can be saved by the use of a photo-electric cell which will automatically switch off the lights when the intensity of natural light reaches a pre-determined level.⁵ It is thought, although not conclusively proved, that better growth of some plants can be obtained by regulating glasshouse temperature according to light intensity rather than by maintaining a constant temperature. The N.I.A.E. "Solarstat"⁶ and the "Luvatherm"⁷ have been designed to vary temperature in proportion to light intensity.

An experienced glasshouse plantsman is always judging a crop and applying the necessary treatment, such as the variation in the watering

and feeding regime to maintain the desired type of growth. A less experienced man, no matter how conscientious, often will not detect the need for a change in treatment as quickly, resulting in a loss of yield or quality or both. Timing and application of water are particularly difficult to judge but when the final stages of the development work by the N.I.A.E. on a fully automatic watering system⁸ are completed it should be possible for commercial growers to maintain automatically the moisture content of the border soil at the correct level during all stages of plant growth (Plate VIII).

High Capital Costs

Many automatic systems are complex and some have only special applications resulting in high capital costs and maintenance problems. While every effort is made to produce simple equipment this is not always possible. The more complex units are therefore limited to the large intensive production units where the throughput justifies the capital expenditure and specialist maintenance facilities can be provided. For these reasons automation has been applied mainly to the intensive sections of the industry such as glasshouse production and controlled stores for fruit, vegetables, bulbs, and flowers.

SIMPLIFICATION IN THE LONG RUN

As development work continues simpler ways of achieving similar results to those being obtained now with fairly complex equipment will be produced. Automation of glasshouse heating and ventilation is an example of this type of development. In order to achieve accurate control of heating and ventilation in a glasshouse the two systems have to be controlled in sequence from one thermostat.⁹ In addition a system must be employed which will allow the ventilators to take up any position between fully open and fully closed, the exact position being determined by the deviation of air temperature from the desired value, i.e., proportional control.

"On-off" control, which is employed on many applications, would be obviously quite unsuitable for the control of ventilators which would then be either fully open or closed. Proportional control from one thermostat can be achieved by the use of relatively expensive and complex electronic equipment suitable for research stations but unsuitable for the average commercial grower. However, it is now possible to obtain almost equally good control with much cheaper and simpler equipment. In the system designed at the N.I.A.E. the air thermostat actuates the ventilator opening mechanism which in turn either controls the degree of opening of the ventilators or operates the heating system.

Looking into the Future

Rapid development of automation in other industries will assist automation in horticulture by the improvement of the type and range of

equipment available, possibly coupled with a reduction in price due to increased production. However, even in the most favourable horticultural enterprises complete automation is still a very long way off, though during the next decade it is certain that there will be improvements in many of the existing systems and greater use will be made of these where it is economically sound to do so. In addition to automation it is probable that some jobs such as the production of young plants, the harvesting of some crops and handling of materials and produce, at present done manually, will be mechanized, particularly on the larger and intensive holdings.

Automation can only be justified economically where there is intensive production and where benefits can be obtained over a number of years. In the glasshouse industry future developments could include fully automatic watering of pot plants, a task which at present has a high labour demand, and automatic control of atmosphere in the glasshouse, particularly the CO₂ concentration in relation to light, to achieve higher growth rates.

Outside the glasshouse industry, packing sheds and orchards have features which are favourable to automation. With the increase in co-operative marketing the average amount of produce handled per packing shed will increase considerably, and on many of the larger units industrial techniques and machines such as automatic packing, weighing and box sealing units could be economically applied. Orchards, which once planted are not materially changed in layout for many years and which require many tractor operations each year, e.g., grass cutting, spraying, and fertilizer applications, would appear to offer greater possibilities of automation than any other type of field work. The energized wire system of guidance¹⁰ could be employed. This would result in a direct saving of labour, and in the case of spraying, improved application due to the ability to spray at night when conditions are frequently more favourable than during the day; the possibility of reducing the number of tractors by more intensive use must also be borne in mind.

Automation of one part of an enterprise may result in a general reduction of the labour force and this could adversely effect other seasonal work on the holding. Hence management as well as economic and technical aspects of automation have to be carefully considered in the planning stage.

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Soil Acidity—Assessment using Soil Indicators

N.A.A.S. Advisory Soil Chemists' Conference

SOIL INDICATORS are used both in the field and in the laboratory for assessing the degree of acidity of soils. Only a very rough classification of acidity is possible in the field into “very acid”, “moderately acid”, “slightly acid”, and “not acid”. In the laboratory, a rough or very close estimate of pH may be made according to the technique employed, but it is usual and preferable to use a pH meter with a glass electrode.

With mixed indicators as used in the field, close accuracy in assessment of pH is not possible because of two main sources of error, which are: (1) the colours of mixed indicators may be altered by clay and organic matter absorbing some of the dye constituents, (2) the yellow colour of some silt soils and the reddish orange of other silty soils may mask the colour of the indicator. In addition some people suffer from varying degrees of colour blindness which makes it difficult to assess shades of colour.

Composition of a Mixed Indicator

The following mixed indicator has been found to perform fairly satisfactorily on a wide range of soil types:

- Methyl red 0.4 g (Hopkin and Williams code No. 5786).
- Bromothymol blue 0.8 g (Hopkin and Williams code No. 2376).
- Rectified spirit 800 ml.
- Saturated lime-water, about 80 ml.
- Distilled water to make the final volume 4 litres.

Some grades of industrial spirit may be used in place of rectified spirit, but each batch should be examined for suitability by comparison with

rectified spirit. Methylated spirits often change the colour range and shades of the indicator.

Preparation

Grind and sieve the methyl red through a 70 I.M.M. sieve. Dissolve in 400 ml rectified spirit.

Dissolve the bromothymol blue in 400 ml rectified spirit; mix the two solutions together and add to about 3 litres of distilled water.

Add a saturated solution of lime-water until the colour becomes green (pH about 7.3) and dilute to 4 litres with distilled water.

For field use, transfer to 100 ml spouted glass bottles that release alkali very slowly from the glass surface.

Method in the Field

The dish technique is the most suitable for general field use. The dish should be made of white porcelain, which provides the best background for seeing colours, or of glass, but not of polythene which may affect the colour of the indicator. The dish should be clean and tested by rinsing with a little soil indicator before use. A fragment of soil is dropped into the dish and a little indicator then poured in; contact between the soil and indicator is achieved by slowly rocking the dish so as to avoid as far as possible breaking up the soil fragment and the formation of a muddy suspension. After the indicator has soaked into the soil fragment the colour at the junction of the soil and indicator should be used to assess the acidity of the soil; sometimes, especially with peaty soils, this colour is very different from that of the rest of the indicator. At no stage should the indicator make contact with the fingers or be stirred with pieces of straw or twig, which commonly change the indicator colour. It may be an advantage to add neutral and salt-free barium sulphate to the indicator and soil, to obtain greater clarity of colour with soils that are coloured and tend to slake readily in the indicator.

Method in the Laboratory

The soil should be shaken fairly vigorously with barium sulphate and distilled water in a glass test-tube in the proportions of 1 soil, $\frac{1}{2}$ to 1 barium sulphate, and $2\frac{1}{2}$ water by volume. After the soil has settled, the indicator should be added, and the tube stoppered and gently inverted once or twice and the soil allowed to settle again. This procedure results in less absorption of the indicator by the soil than shaking all together vigorously, and colours are more reliable.

Colour Changes of the Indicator

The colour changes of this indicator with soils under favourable conditions are as follows:

Colour of indicator at junction with soil	Probable pH range of soil	Classification of acidity
RED shades	<4.8	Very acid
ORANGE	4.8-5.2	Acid
ORANGE/YELLOW	5.3-5.7	Moderately acid
YELLOW shades	5.8-6.5	Slightly acid
GREEN to BLUE shades	over 6.5	Not acid

Technique in the Field

Cores of soil should be tested in various parts of a field and notice taken whether they contain fragments of chalk. If varying acidity is found, areas of similar acidity should be roughly mapped. The depth of acidity in these areas should then be investigated.

Estimate of Lime Requirements

pH determination alone will not give an estimate of lime requirement. This requires considerable knowledge of local soils and an assessment of soil texture and organic matter content. It is suggested that the advice of the Regional Soil Chemist should be obtained on this.

Taking a Look at Training

JOHN ANDERSON

N.A.A.S. Eastern Region

THE PURPOSE of training is two-fold; firstly, to instil in the new adviser confidence and ease in facing his new task, to give him the ability to deal adequately with the general run of problems he is likely to come across in the sphere in which he operates; and, secondly, to develop in him the capacity to shoulder greater responsibilities as he rises in the Service, and so lay the foundation of his career right from the start.

Mutual Confidence

Training involves bringing together two personalities, the teacher and the pupil. In order to achieve the best results confidence and respect has to grow mutually on both sides. The trainee has to be made to feel that he is welcome in his new circle, that his employers think it worth while spending money and time in continuing the education he obtained at his University, and applying it to conditions in the field.

It is all too easy to give the newcomer the impression that he comes empty-handed to his new job and to ignore the fact that his knowledge of agricultural science will not yet have tarnished, as may that of his older colleagues. True he may lack the practical wisdom and sound

judgment which the teacher has laboriously acquired over the years, but much can be added to what the novice already has without insisting on the seasoning effect of time.

RESPONSIBILITY OF THE TEACHER

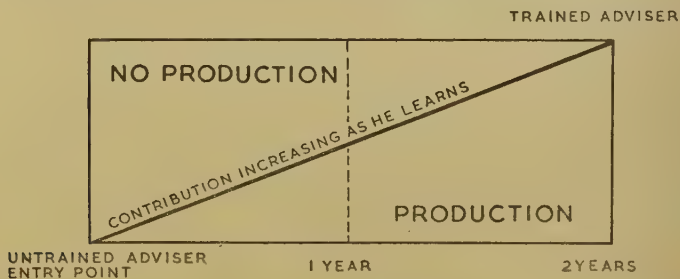
A great responsibility rests upon the teacher if his charge is to absorb so much new information in the strange surroundings of his first job, and at the same time maintain enthusiasm and receptiveness at a high pitch. No doubt some experienced advisers are better at establishing good relations with young people than others. These are the men who should be most closely concerned with training the new entrant at County and Regional level, for their long-term effect on the Service could be immeasurable.

A new entrant, receiving a fairly generous salary and allowances, represents a considerable charge upon the Exchequer for the first few years of his service, before he is able to shoulder the full responsibility of his post. During this time his level of experience, though rising, limits the scope of the advisory work he is able to do. The object of his training programme must be to bring him to the point of full contribution as quickly as possible.

Assessment of Progress

An untrained adviser is an expensive item in the budget. Training him is expensive too, and it may be worth while trying to determine the level of expense which would be justified in training a new entrant to bring him into productive action with the least delay.

Our American extension friends, with their interest in gathering and applying data, have gone into this matter in some detail. Translating their terms to those more familiar to us in the N.A.A.S., their assessment of the progress of the general agricultural adviser—and indeed that of the young specialist too—is broadly as follows:



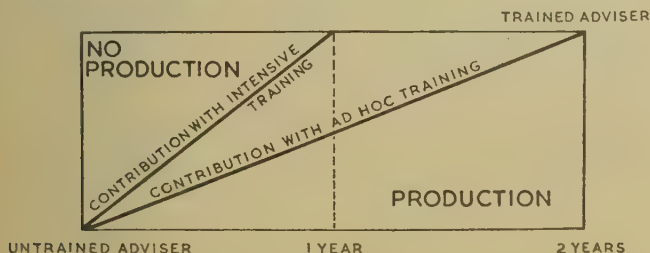
When he takes up his duties, a grade IV (general agriculture) officer will make little contribution to the work of his county. As he learns, his

contribution becomes progressively greater until, after two years or so, he has acquired sufficient experience to assume the responsibility of his own district. Over the two year period, therefore, his output as an adviser is about half what it would have been if he had been fully trained at the start.

THE BALANCE SHEET

In terms of £ s. d. an imaginary balance sheet will show, at the end of two years—on the debit side—sums representing his salary, official maintenance and accommodation, travelling and subsistence expenses, in all totalling, say, £2,500, which the Department has spent to get him into full production. On the credit side we could imagine that over a similar period his contribution to carrying the load would amount to about half that of a fully trained adviser. Thus, about £1,200 has been the cost of gathering experience—of his training.

Now, if it were possible for the trainee to absorb instruction at an intensity sufficient to fit him for full responsibility in one year instead of two, our diagram would look like this:



The area of no production has been reduced by half, his output during the two years represents three quarters of the productivity of a fully trained adviser, and the cost of his training has been reduced by half.

On this evidence, an advisory service with an annual entry of, say, 60 recruits could afford to spend as much as £36,000 on such intensive training of its new advisers as would bring them to full production in half the normal time. True, there may well be professional jobs for which the training cannot be so condensed, and there are always limitations to the speed with which a man can learn. But the principle holds that the learning period is expensive, and the less one does about it the more expensive it becomes. Good new entrants come into the N.A.A.S. each year. It is clearly in everybody's interest that their progress towards efficiency should be as rapid as possible, and all means to this end will exercise the minds of those who carry the heavy, but immensely rewarding, task of teaching the new-comer.

The Pattern of Training as a Whole

The initial training given to the new recruit—often called induction training—is so closely tied to what follows, and has, or should have, such a strong influence on the subsequent course of events that one feels bound to incorporate one's observations on it in the wider context of training as a whole.

ARRIVAL OF THE NEW ENTRANT

Induction training commences the moment the new entrant arrives at the place where he is going to work. Here he will learn something about the local organization with whom he will work, what his particular job will be, and so on, in a fairly informal atmosphere. The more formal part of his induction training commences when he attends the New Entrants Course. Those responsible for the arrangements for this important event have always made a clear distinction between induction training and in-service training. In fact, the induction phase of training is not a training course in the true sense of the word. It doesn't primarily set out to teach new skills, so much as to give the participants essential background knowledge.

He has joined a new organization, is eager to know something about it, what it does, how it does it, and what will be his own role. He will need to know about the Civil Service, the Ministry, the N.A.A.S., and something about the structure of the farming industry, its needs and its contributions. He will not only meet all those people who joined at the same time as he did, but also a cross-section of colleagues already in post who will tell him something about their role in the Service and how the work of each dovetails in with the others. Care is obviously taken in an intensive course of this kind to leave out anything which could profitably be given to the trainee when he takes up his post in the Region. Conversely, nothing must be omitted which only this course could provide and which, if lost, is gone for good.

This early meeting of new entrants provides a good opportunity to say something about the planned programme of training—a programme designed to strengthen the weak points in previous experience and one which is personally tailored to each new entrant. The induction course is the first time the new adviser will come into contact with the leaders of the Service, men experienced in advisory work and training. The new-comer will be in a keenly receptive frame of mind, anxious to learn all he can from them, and it is worth taking a good deal of trouble to ensure that he feels he has joined a friendly, helpful, enthusiastic, and obviously successful organization. A good impression made at this stage might well remain with him all his Service life.

PERSONAL TRAINING PLAN

Once the new recruit has been given his bearings in this short induction training course, he returns to his post, and becomes subject to

his own personal training plan, more intensive perhaps in his first two years, but continuing with lessened tempo throughout the whole of his Service.

In his early days in county or department the emphasis will be on teaching the new adviser how to perform the duties appropriate to his job, to show him the tools he will need and to give him confidence in using them, with the objective of making him a useful member of the team with the least delay. Perhaps we should recognize this particular aim by referring to it as "production training". This is not a passive exercise; the new entrant must take every opportunity to inform and educate himself, and to make known to his supervisor such needs as he feels are not fully being met. If he is required to furnish a report from time to time on his progress, attention will quickly be drawn to any shortcomings in the training programme.

Once he becomes fairly well fledged and has cleared the first promotion hurdle, he needs to be kept up to date, to hear of new ideas, new techniques and developments which have come into prominence since he completed his academic training. His basic knowledge of husbandry and science may require refurbishing. This aspect of his training is variously achieved by attendance at conferences, membership of professional bodies, visits to Research Stations and Experimental Farms as well as through refresher courses of short duration—refresher training can be somewhat of a misnomer, however, since one may hardly refresh what one has not previously experienced. "Maintenance training" would perhaps be a more descriptive title. Whatever it is called, its objectives will be to keep the adviser at the peak of his powers, by maintaining his knowledge and adding to it as new developments take place.

A Good and Satisfactory Career

One of the basic principles of the N.A.A.S. is that it must offer opportunities to the right man to develop a good and satisfactory career. If the Service is to maintain its high ideals, the training of those who will ultimately hold higher posts within it and be responsible for its leadership is a matter of great moment. Training an officer for a higher position does not necessarily relate to the job he is currently doing; rather should it be designed to broaden his outlook and his experiences, to encourage him to think about the duties he may one day be called upon to discharge, and in this an element of self-improvement will be a key factor.

Those who already hold deputy posts may have the advantage of working closely with a supervisor, of understudying him in many of the duties he performs but, none-the-less, those who are not in this privileged capacity have many ways in which they can acquire training with the future in mind. Specialization in some important aspect of advisory work, membership of Regional and County committees, participation in working parties and other ad hoc groups concerned with the life and

work of the Service all offer invaluable opportunities for widening routine experience.

The effect upon the stature of the Service tomorrow can be so markedly influenced by carefully planned developmental training of this kind, that it merits our closest consideration.

Regional Note

Meetings and Farm Walks for Bank Managers

GEORGE PRECIOUS

National Agricultural Advisory Service (Staffordshire)

WITH THE object of establishing a closer working relationship between farmers, bankers, and advisory officers, the N.A.A.S. in this county has during the past five or six years arranged a series of private meetings and farm walks for bank managers.

The meetings were designed to stimulate the bankers' interest in the work of the N.A.A.S. From the beginning the bank managers showed a keen interest in N.A.A.S. activities and the role the service plays in the business of farming. Since the first meeting, contact has been continuous and a clearer understanding of each other's work has developed.

Demand for Farm Management Advice

The important role that bank managers play in farming businesses becomes more evident to the N.A.A.S. as the demand for farm management advice increases. Irrespective of whether the bank managers are drawn from rural or urban districts, the majority who attend these events have some knowledge of agriculture, but a much smaller proportion have direct contact with the practical side and the day-to-day problems of farming.

LOCAL ARRANGEMENTS

Meetings are arranged through the local secretary of the Institute of Bankers, an organization to which most bank officials belong. The local branches of the association draw their members from a wide area; in consequence, it is possible to cover a whole county with few meetings. The Institute's yearly programme generally includes guest speakers drawn from various sections of commerce and science, and an offer to provide speakers on agricultural topics is usually welcomed. In districts where the local branch is not active, there is no difficulty in getting the bankers to attend meetings organized by the N.A.A.S., either through personal contact or by written private invitations.

Choosing a convenient day and date to suit every bank manager is not easy. The periods of the bank's half yearly balance, market days, or days when local industries make heavy demands on the bank staff must be avoided. Meetings should be timed for 2.30 p.m. onwards, when most banks are closed to customers. On these small, but important points, the experience and help of the secretary of the Institute of Bankers is invaluable.

Input Costs and Average Returns

At the initial meetings, a general description of the farming in the county is given, special reference being made to the district which the local banks serve. The area of agricultural land, the proportion of arable and grassland, the number and average size of holdings are given. Trends in crops and livestock, the farm labour force and production figures are enumerated.

Special reference is made to input costs and average returns per acre from different cropping systems and livestock enterprises. Slides and graphs are used as lecture aids; for example, one of the things illustrated is the declining labour force, coupled with increased mechanization, which in turn is related to the increase in the capital required for farm equipment.

FARM MANAGEMENT EXERCISE

The structure of the N.A.A.S., its functions and how the service fits into the general pattern of the agricultural industry form a general introduction by the C.A.O. or his deputy. Then the D.A.O. gives a simple example of a farm management exercise on a typical farm for the district. The audience, which may range from twelve to forty bank managers per meeting, are taken through the whole exercise, from "walking" the farm, collection of cropping and stocking data, to the final analysis sheet and revised farm plan.

Each member of the audience is supplied with a copy of the specimen worksheet and follows the D.A.O. through the exercise. This is a great help to the bankers who make notes and mark sections which require further explanation. The specimen worksheets are prepared in such a way that they can be taken away by the members for further study and reference.

N.A.A.S. officers are advised to be particularly well briefed before facing an audience of bankers, and prepared for some extremely searching questions on husbandry and management matters. In addition, they may be asked to deal with capital budgeting, budget control, fixed and variable costs. Questions on high output and high profits, produced over a short period which may be at the expense of soil fertility and the risk of disease in crops and livestock, need to be answered clearly without getting technically involved. Keen interest is shown in examples where the farmers' total receipts have decreased but the profits have increased.

Putting Advice into Practice

Once the bankers' interest in the work of the N.A.A.S. has been stimulated, requests to see the advice put into practice were to be expected. In consequence, private farm walks are now a feature of the Institute of Bankers' yearly programme of events. The farm walks follow a similar pattern to that of the indoor meetings, except that they need a great deal more planning in advance.

Although most farmers who have benefited from farm management advice are prepared to co-operate in arranging a farm walk, choosing a suitable farm is not easy. The farmer must be prepared to disclose his financial position and it is an advantage if he can do some of the talking. Owing to the time factor, bank managers are not keen on travelling great distances and it is better if the farm is within a five to ten mile radius of the town centre. As the visit is private and the route not signposted, it is advisable to include a direction map with the invitations.

In the upland areas of North Staffordshire, the husbandry and economic problems of the small farmers have been demonstrated. The

Upland Dairy Farm, North-east Staffordshire

EXPANSION OUT OF PROFITS

Item	Years of the plan					Year after completion of the plan
	1st	2nd	3rd	4th	5th	
<i>Additional expenses and income foregone</i>	£	£	£	£	£	£
Cows	90	180	90	180	180	—
Ditching (Gross)	100	45	—	40	—	—
Feedingstuffs	40	120	160	240	320	320
Fertilizer	60	60	60	60	60	60
Cultivations	30	30	20	20	20	20
Seeds	45	30	—	—	—	—
Overheads	4	9	13	22	22	22
Replacements	—	30	30	30	30	30
<i>Total additional expenses etc.</i>	369	504	373	592	632	452
<i>Additional income and costs saved</i>						
Milk	105	315	420	630	840	840
Calves	5	5	10	15	15	15
Saving in Feed	40	60	70	80	100	100
Ditching Grant	50	—	—	—	—	—
Ploughing Grant	60	—	—	—	—	—
S.F.S. Grants	314	358	288	50	—	—
<i>Total additional income etc.</i>	574	738	788	775	955	955
<i>Additional income less additional expenditure</i>	+205	+234	+415	+183	+323	+503
<i>Accumulated Balance</i>	+205	+439	+854	+1,037	+1,360	—

EXPANSION USING CREDIT

Item	Year of the plan					Year after completion of the plan
	1st	2nd	3rd	4th	5th	
<i>Additional expenses and income foregone</i>						
Dairy Cows	800	800	—	—	—	—
Interest	56	89	67	45	22	—
Loan Repayment	320	320	320	320	320	—
Feedingstuffs	400	800	800	800	800	800
Fertilizer	160	160	200	200	200	200
Cultivations	30	30	20	20	20	20
Seeds	45	30	—	—	—	—
Overheads	40	40	40	40	40	40
Ditching	100	45	—	40	—	20
Replacement of Cows	—	—	80	80	80	80
<i>Total additional expenses etc.</i>	1,951	2,314	1,527	1,545	1,482	1,160
<i>Additional income and costs saved</i>						
Milk	1,050	2,100	2,100	2,100	2,100	2,100
Calves	25	50	50	50	50	50
Saving in Feed	—	—	20	40	60	100
Ditching Grant	50	—	—	—	—	—
Ploughing Grant	60	—	—	—	—	—
Saving in Labour	300	400	400	400	400	400
S.F.S. Grants	314	358	288	50	—	—
<i>Total Additional Income etc.</i>	1,849	2,908	2,858	2,640	2,610	2,650
<i>Additional income Less additional expenditure</i>	-102	+594	+1,311	+1,095	+1,128	+1,490
<i>Accumulated Balance</i>	-102	+492	+1,823	+2,918	+4,046	—

In both cases the milk price is based on a figure that allows about £10 per cow per year towards the cost of her replacement. For this reason replacement costs are not shown to be as high as most people would find them.

In plan B the cost of the cows is spread over the first two years. These could all have been bought in the first year. A policy of slow buying of the right cows rather than a bulk purchase was advised.

output from new leys is compared with that of worn out turf. The effects of efficient land drainage systems, well maintained ditches, and the response of the crops to varying rates of fertilizer applications creates interest and many questions are asked. Practical things like the factors governing the choice of parlour, the implications of self-feeding, and the overall reduction in the labour required give rise to interesting discussion. What the advisory officer considers to be an elementary issue may develop into involved questioning—bankers' minds probe deeply.

Farm walks are usually terminated by the presentation of the financial data. Aided by graphs and charts, the "before and after" story is told. Comparing the farm walks with meetings, it is obvious that the bankers obtain a better appreciation of the problems on the farm where the farmer takes part in the discussion.

At one of the farm walks in North Staffordshire the farmer agreed to representatives of the press attending. Here the bankers could see the practical results of expansion using credit and the benefits to the farmer of short term borrowing. This was compared with the slow growth of expansion from profits. N.A.A.S. speakers emphasized that increased borrowing must be backed by an economically sound long term plan that will enable the farm to stand on its own feet as a viable unit.

Details of the capital requirements on this 62 acre farm gave the bankers an idea of the amount of money involved.

In this county, five bankers' farm walks have already taken place. Visits have ranged from the small upland holding to large lowland arable farms, and have demonstrated the input and output data for different enterprises over a wide range of geographical and climatic conditions.

Problems connected with New Entrants to Farming

One of the most difficult problems facing both bankers and advisory officers is where no accounts exist, as in the case of the new entrant to farming. Costs and returns must be calculated from average input and output data. Capital requirements must be assessed by means of capital budgets. The great problem is assessing the managerial capacity of the new entrant. Average input and output data will give reasonable answers if the managerial capacity is also average.

Since the would-be farmer may be above or below the average, the experienced advisory officer introduces at an early stage a method of business control by either monthly or quarterly forward budgets, which are checked against the actual performance. This enables the farm plan to be modified and the husbandry advice directed towards correcting faults at an early stage. On one farm, where the farmer had started farming nine months earlier, this method of business control was demonstrated to bankers. Details of the capital budget and the business control methods adopted created a great deal of interest.

Looking to the Future

Attendance at these farm walks may vary from twelve bank managers to over eighty bank officials at evening events, when bank accountants, cashiers, and clerks may be present. As today's bank clerks may be the bank managers of tomorrow, the N.A.A.S. welcomes their attendance.

A familiar advertisement in the farming press depicts two men walking the farm, presumably the farmer and a neighbour. The caption reads: "It pays to put the third man in the picture, you'll find him at ——— Bank". In Staffordshire, you could find him on the farm.

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